Opportunistic Data Transmission

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***Abstract*—Providing connectivity in scenarios where nodes present a very dynamic behavior is quite challenging due to resulting link intermittency among user devices. In such a challenged scenario, opportunistic contacts can be used to perform data forwarding. Moreover, as these moving nodes are carried by humans, taking into account the users' interests, social relationships, and mobility behavior may provide the required support to develop more efficient routing protocols. This paper provides a brief overview concerning opportunistic data transmission, highlighting the different flavors of opportunistic forwarding solutions as well as the ones product of COPELABS.**

Keywords*—*opportunistic data transmission; users' daily routines, users' interests;

I. INTRODUCTION

Today's scenario comprises users with a very dynamic behavior, producing and consuming a vast amount of data as shown in Fig. 1. Thus, providing connectivity in such scenario is rather challenging since wireless links may be intermittent. Moreover, intermittent connectivity may be due to shadowed areas such as inside buildings and metropolitan transportation system, as well as public areas with closed broadcast access points. Such intermittency results in long delays, and potential disrupted communications due to the inability of routing protocols to find end-to-end paths between a specific source/destination pair.

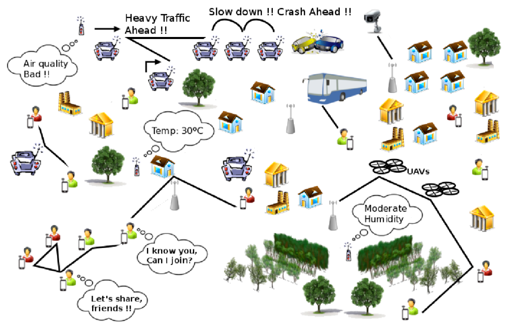

Fig. 1. Current scenario.

Opportunistic data transmission can be used to overcome link intermittency as it takes advantage of the contacts between users to relay content until the final destination is reached. This paper showcases the solutions devised in COPELABS in this direction. It starts by briefly presenting what opportunistic data dissemination is and few of its flavors (Sec. 2). Then, a brief overview is given concerning two products of COPELABS regarding opportunistic data transmission, namely dLife and SCORP (Sec. 3). Finally, the paper is concluded with a few insights on future steps (Sec. 4).

II. OPPORTUNISTIC DATA TRANSMISSION

Sporadic contacts taking place between users may create forwarding opportunities even when an end-to-end path is absent (cf. Fig. 2).

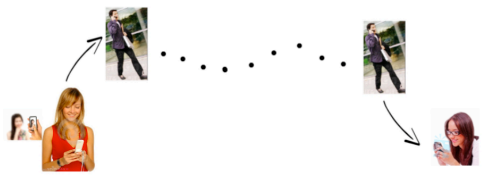

Fig. 2. Example of opportunistic data transmission.

This feature of opportunistic data transmission has led to appearance of different forwarding approaches, ranging from flooding the network to achieve a fast delivery of information (e.g., Epidemic [1]) up to solutions that control replication based, for instance, on: delivery probability optimizations (e.g., Spray and Wait [2]); history of encounters between mobile devices (e.g., PROPHET [3]).

Among these solutions, a trend emerged considering not only node mobility patterns but also the existing social similarity metrics among users [4], which consist of i) labeling users according to their work affiliation (e.g., Label [5]); ii) looking at the importance (i.e., popularity) of nodes (e.g., PeopleRank [6]); iii) using centrality and the notion of community (e.g., Bubble Rap [7]); iv) considering interests that users have in common (e.g., SocialCast [8]); v) inferring different levels of social interactions aiming at predicting future social interactions from the users' dynamic behavior found in their daily life routines (e.g., dLife [9, 10] and CiPRO [11]); vi) combining social information and content knowledge (e.g., ContentPlace [12] and SCORP [13]).

The work developed in COPELABS follows such trend and focuses on how users socially engage to allow data exchange as presented next.

III. OUR SOLUTIONS

Since people have daily routines with different levels of social engagement [14], our solutions for opportunistic data transmission focus on the contact duration between nodes at different moments in time. Within this context, this section starts by introducing the devised utility functions, followed by our opportunistic forwarding solutions.

A. Utility Functions

Our opportunistic forwarding solutions consider one or more of the following utility functions [15]:

Time-Evolving Contact Duration (TECD) derives the social weight based on the statistical contact duration that nodes have over time. TECD encompasses: i) the duration of contacts, representing the intensity of social ties among users; and, ii) time-evolving social ties, reflecting users' habits over different time periods. The social weight given by TECD refers to the *probability of meeting nodes with same social daily routine*.

TECD Importance (TECDi) computes the importance of a node, considering its social weights towards its neighboring nodes as well as their importances.

Time-Evolving Contact to Interest (TECI) considers the interests of users on the data traversing the network. This means that the social weight given by TECI reflects the *probability of meeting nodes with a given interest among those which have similar social daily routine*.

B. Opportunistic Routing based on Daily Life Routine (dLife)

dLife [9, 10] captures the dynamics of users' social behavior found in their daily routines. This allows the solution to better take advantage of sporadic contacts to improve data delivery: data is exchanged among users with high probability to meet (i.e., users that are socially well-connected with) the destination.

dLife decides to replicate messages based on the TECD and TECDi: if the encountered node has better relationship with the destination, it receives the data. By having higher weight (i.e., high social relationship), there is a much greater chance for the encountered node to meet the destination in the future. If the relationship to destination is unknown, replication only happens if the encountered node has higher importance than the node carrying the data.

C. Social-aware Content-based Opportunistic Routing Protocol (SCORP)

With SCORP [13], data arrives at interested parties as they socially interact. By combining social (i.e., levels of social interaction) and data (i.e., type of content) information, data is exchanged among nodes with high probability to meet nodes interested on that data.

SCORP employs the TECI utility function to shift focus from the hosts to the data, thus introducing data knowledge and becoming able to perform point-to-multipoint delivery. Thus, SCORP exploits social proximity and content knowledge to augment the efficiency of data delivery in urban, dense scenarios.

SCORP is expected to replicate only to nodes that do have interest in the data to be forwarded, or that are socially well connected to other nodes that have that specific interest.

IV. Conclusions and Future Steps

Opportunistic data transmission may benefit when social similarity metrics (e.g., popularity, level of social interactions, shared interests) are employed.

This paper showcases solutions devised in COPELABS towards this direction, namely dLife and SCORP. The former forwards data based on the different levels of social interaction among users and their importance in the system. The latter considers the interests between socially well connected users to decide when to forward data.

Both solutions have shown great potential and are now being implemented for real world applications in which social entanglement and users interests are used to perform opportunistic data transmission, namely asynchronous messaging and interest-based opportunistic information dissemination. Our solutions are also to be incorporated in the UMobile European Project that encompasses DTN/ICN concepts users' social interactions, interests and trust circles.

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